# GFZ Analysis Center of IGS - Annual Report for 2002

*Gerd Gendt, Maorong Ge, Feipeng Zhang*
GeoForschungsZentrum Potsdam, Department Geodesy & Remote Sensing
Telegrafenberg A 17,
14473 Potsdam, Germany; e-mail: gendt@gfz-potsdam.de

**Summary**

The changes introduced during 2002 and early 2003 are summarized in Table 1. They were focused on the improvement in the product quality and in the robustness of the analysis strategy.

Table 1. Changes in the analysis strategy

| Week | Date | Description |
|---|---|---|
| 1168 | 2002-05-30 | Introduction of new single site data cleaning strategy |
| 1172 | 2002-06-23 | Use of UT1 instead of UT1R |
| 1174 | 2002-07-07 | Loosing the a-priori orbit sigma during its eliminations from the SNX-file (old: ~0.1 m resp. m/d new: ~ 1 m resp. m/d) |
| 1179 | 2002-08-11 | Extension of used IGS network to 150 stations via cluster strategy |
| 1184 | 2002-09-19 | Rapid products with concatenation of two days |
| 1189 | 2002-10-20 | Introduction of new sp3c-format |
| 1202 | 2003-01-19 | Introduction of ambiguity fixing into Rapid analysis |
| 1214 | 2003-04-13 | Enlargement of network (~50 station) for Rapid analysis |

## Data Cleaning

The data are cleaned iteratively by scanning the post-fit residuals from the network solution. The number of iterations needed for obtaining a clean data set depends heavily on the quality of the GPS data the procedure start with, as large cycle slips will bias the residuals in the network solution. To speed up the clean procedure a single station data clean strategy is implemented as described by Blewitt (1990) to flag and repair as many cycle slips as possible before starting the network analysis. It is well known that the method fails when the pseudo range observations are not good enough. This is unfortunately true for a number of stations as our network is extended to more than 150 sites. Rapid ionosphere changes can also lead to erroneously removal of good observations. To overcome those problems, we reduce the geometric effect from the ionosphere-free phase observation and fit the difference between satellites piece by piece for data without SA clock dithering. The rms and the residuals of the fitted observations give an additional quality index along with wide-lane and ionosphere change for making a decision on the observation quality. The new software has been introduced into our routine data processing since May 30, 2003. For non-SA data the remaining cycle slips detected in the later iterative procedure are in average no more than 4% of all the cycle slips over all the 150 stations and their values are rarely larger than 1 cycle in L1 wavelength. This is especially effective for our ultra-rapid and rapid processing where precise satellite clock information is not yet available for cleaning the data station by station using the precise point positioning technique as it is done for the Final analysis.

## Rapid Products

Whereas the quality of the GFZ Final orbits has reached a level of 2 cm during 2001 the quality of the GFZ Rapid products with 5 to 6 cm has not improved significantly throughout the last years. Therefore efforts were made to utilize elements from the Final analysis also here. One orbit-stabilizing factor in the Final analysis is that three-day orbits are used to get the best orbit solution for the middle day, avoiding orbit problems at the day boundaries. For the Rapid orbit two days were concatenated and the second day is taken as the product. However, the most visible progress in the orbit quality was gained by the introduction of the ambiguity fixing (Fig. 1). This was feasible because the robustness of the ambiguity fixing was improved recently so that it could be introduced into the automated analysis for the Rapid products.

Additionally, the selected station set was enlarged from ~35 to ~50 so that the realization of the reference frame will be less effected by the available station data.

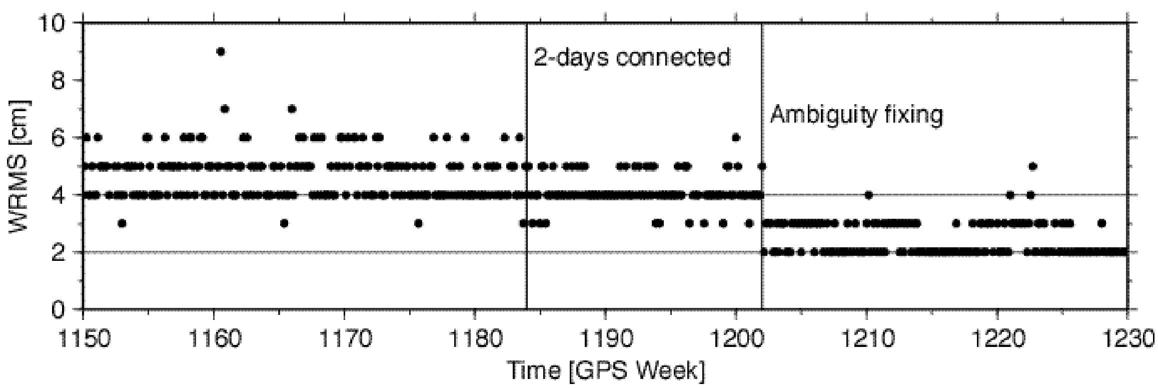


Fig. 1. Quality of the various GFZ satellite orbit products taken from the official combinations reports

## Final Products

To extend our IGS final network, we process data in a cluster mode for saving computer time and overcoming computer memory limitation. We divided all the stations to be processed into several clusters. Each cluster includes no more than 80 stations. That is for the moment the most economic station number for EPOS running on our mainframe computer. A set of common stations is necessary to be included in each cluster as the reference network for connecting the clusters. Each cluster is processed independently similar to usual GFZ final data processing strategy by calling standard EPOS procedures. The cluster (named 'IGS base') for generating IGS orbit and clock is processed at first, so that its products can be used for cleaning the data of the other clusters by scanning precise point positioning residuals. Each cluster provides a normal equation with station coordinate, orbit and earth rotation parameters. Daily normal equations of several clusters are combined together to generate a daily normal equation with all station coordinate and unique orbit and earth rotation parameters for further processing. With this strategy we enlarged our IGS network to about 150 stations and integrated TIGA stations into our routine data processing effectively.

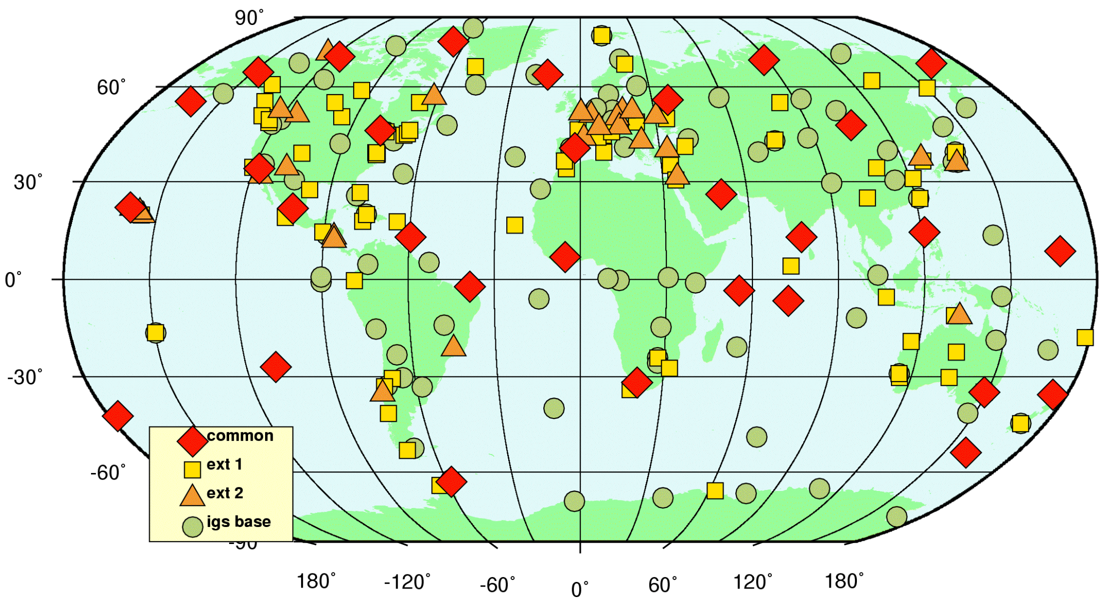

Fig. 2. IGS station distribution and cluster definition, common stations are included in all clusters

There are 4 clusters now in our routine data processing, the ‘IGS base’ cluster, one TIGA cluster and two IGS extended clusters (named ‘ext1’, ‘ext2’). Figure 2 shows the station distribution of the IGS clusters (the TIGA cluster is shown in Fig.4). To produce a daily solution for IGS or TIGA by normal equation combination, the corresponding cluster solutions are chosen. To generate the IGS solution the clusters ‘IGS base’, ‘ext1’ and ‘ext2’ are combined and to get the TIGA solution the clusters ‘IGS base’, ‘ext1’ and TIGA are used. The common stations are included in all clusters.

We combine 3 daily solutions with appropriate orbit constraint at the day boundaries and output a 3-day normal equation for generating weekly products. The final IGS weekly SINEX solution is obtained by combing seven 3-day normal equations. Fixing the station coordinates and earth rotation parameters to the values in the weekly solution, we repeat the 3-day combination to get the consistent final orbit for each day. With station coordinate, ERP and orbit fixed to the value we got in the last step, we solve for clock again from observation to get the clock estimates submitted to IGS. For the moment, only the ‘IGS base’ cluster is used for final clock estimation.

The solution quality obtained by the new cluster strategy can be seen in Figure 3. The difference to the weekly combined IGS solution has slightly improved by about 1 mm for all components and is approaching ±1 mm and ±4 mm in the horizontal and vertical components respectively.

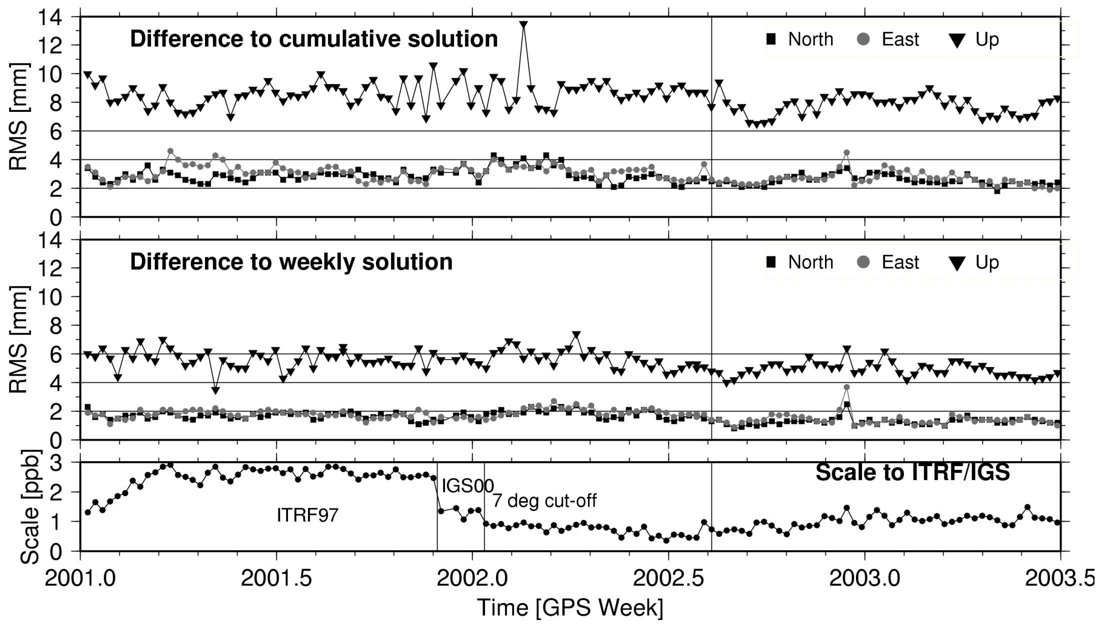


Fig. 3. Quality of GFZ station coordinate solutions extracted from the IGS SINEX combination reports. Since August 2002 the cluster solution strategy was introduced.

## TIGA Data Processing

For the TIGA project, an additional cluster, the TIGA cluster, is defined and processed following the same cluster strategy mentioned above. There are about 80 stations for the moment and Figure 4 shows its distribution. The final TIGA solution comes from combining the TIGA cluster and two IGS clusters as already mentioned. To keep the data set as complete as possible, GPS raw data retrieval is carried out by scanning all TIGA related data centers before starting the job for a day.

At the moment, GFZ is operating three TIGA processing chains. The first chain, with 1-week latency and in parallel with the GFZ/IGS data processing, starts from 2002.0. The second chain, with 460-day latency starting from processing GPS week 1112, is dedicated to TIGA as a permanent routine service. The weekly SINEX solutions are available at ftp://ftp.gfz-potsdam.de/pub/transfer/kg_igs/igstiga/solutions/. The last chain, the backward processing planned to trace back to year 1994, is carried out with a 4-week time step to get a quick look of the time series. This chain started from processing the data of year 2001 and year 1997 is nearly finished now. For consistency, the IGS clusters are reprocessed with the state-of-the-art data processing technique.

To validate the results, the solutions are compared with official IGS solutions and other TIGA AC solutions routinely. Figure 5 gives the rms of the station coordinate differences between the official IGS and the GFZ TIGA weekly solutions (for about 200 weeks) and the number of common stations compared. From Figure 5, the coordinate consistency is ±1 to ±4 mm, and ±5 to ±10 mm in horizontal and vertical directions respectively.

Daily solutions are generated to obtain time series for estimating vertical velocities of TIGA stations. To improve the accuracy of velocity estimation, we are considering applying seasonal variation correction caused by mass loading redistribution derived from geophysical data.

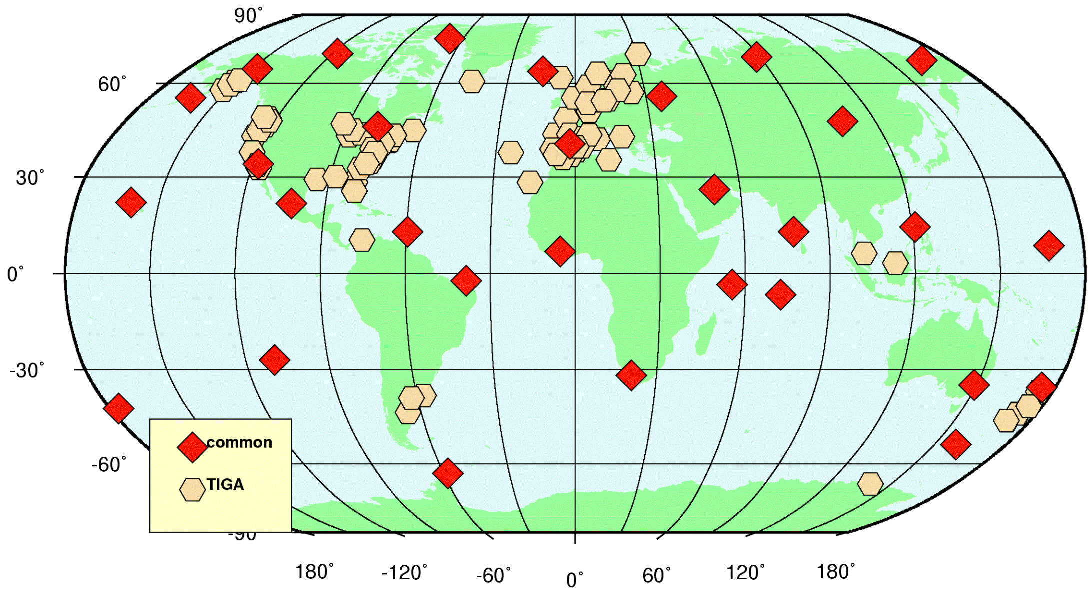


Fig. 4. Geographic distribution of TIGA stations

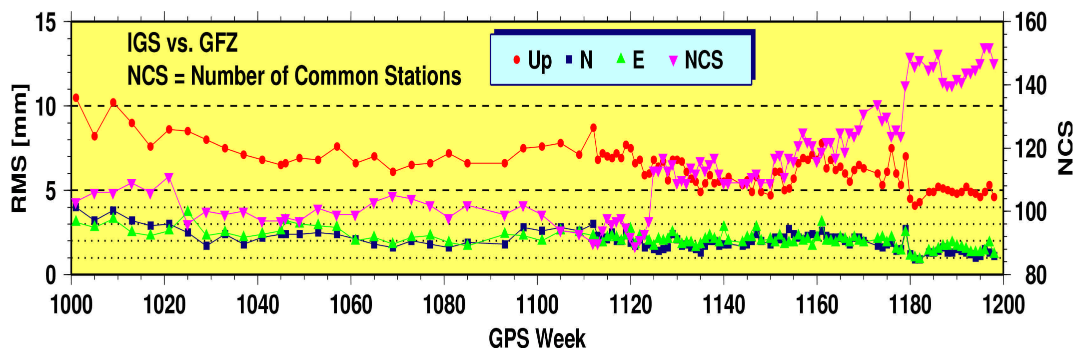


Fig. 5. Comparison between the GFZ/TIGA and the official IGS weekly solutions

## References


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Blewitt G.(1990) An automatic editing algorithm for GPS data, Geophysical Research Letter, Vol. 17 no 3 199-202